EECS 644 HW 6: due 11/11/25

1. From the set of windows we discussed

   a) design lowpass FIR filters using <u>all</u> of the windows that meet the design specs:

   $$\kappa_p = -3 \text{ dB} \quad @ \quad \omega_p = 0.3\pi$$
   $$\kappa_s = -38 \text{ dB} \quad @ \quad \omega_s = 0.32\pi$$

   Plot the resulting magnitude spectra (in dB). *Hint: To approximate the DTFT use 'fft(h,10*N)' which will provide better visibility of the filter sidelobes.*
   Note: you can stop after the initial stage, so do not need to iterate the solution.

   b) What are the tradeoffs between the resulting filters (in terms of N and sidelobe levels)? Which one should you choose based on the design specs, and why?

2. Consider a uniform linear array antenna with $N = 10$ elements at half-wavelength spacing (*i.e.* $d = \lambda/2$) for a particular frequency. For the rectangular beam-taper, use Matlab to plot the receive beam-pattern (in absolute scale) over spatial angle ϕ from –90° to +90° for the receive beam pointed at $\phi = 0$, $\phi = +30°$, and $\phi = +90°$. What do we observe about the relative mainlobe widths for the different steering angles? *Hints: Form a matrix* $\mathbf{S}$ *where each column is a different steering vector* $\mathbf{s}_\theta$ *and then compute* $|\mathbf{S}^H \mathbf{r}|$ *where* $\mathbf{r}$ *is the receive steering vector for each of the three steering angles. Also, use 'linspace' (with 101 points) to establish equidistant points over spatial angle. Note, Matlab assumes the arguments of sinusoid functions are in radians.*

3. For the same physical antenna (*i.e.* the physical distance d between elements does not change), repeat problem 2 but with a new received signal who's frequency is double (so $f_{\text{new}} = 2f_{\text{old}}$). Explain what you observe. *Hint: Recall the relationship between wavelength and frequency (for the signal) of* $\lambda = c/f$, *where c is the speed of light and f is frequency, and compare this to the <u>constant</u> physical distance d.*